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Mechanical Impact Tests of Materials in Oxygen - Effects of Contamination

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Paul M. Ordin

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Paul M. Ordin
Lewis Research Center
Cleveland, Ohio



National Aeronautics
and Space Administration

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Summary

Information is presented on how contaminants affect the mechanical impact sensitivity of Teflon, stainless steel, and aluminum in a high-pressure oxygen environment. Uncontaminated Teflon did not ignite under the test conditions. The liquid contaminants cutting oil, motor lubricating oil, and toolmakers dye caused Teflon to ignite; and raising the temperature lowered the impact energy required for ignition. Stainless steel was insensitive to ignition under the test conditions with the contaminants used. Aluminum appeared to react without contaminants under certain test conditions; however, contamination with cutting oil, motor lubricating oil, and toolmakers dye increased the sensitivity of aluminum to mechanical impact. The grit contaminants silicon dioxide and copper powder did not conclusively affect the sensitivity of aluminum.

Introduction

A number of standard methods for screening (selecting or rejecting) materials for use in oxygen systems have been developed and are reviewed in references 1 to 3. Selections based on the phenomenon of mechanical impact ignition have been particularly helpful and are detailed in reference 4. In this type of test, a falling weight hits a striker pin resting on the sample. The variables usually considered in the mechanical impact tests are temperature, pressure, and sample size. An additional variable included in these tests was contamination. This report presents the results of tests performed with Teflon, 304 stainless steel, and 6061-T6 aluminum at several temperatures and at pressures to 34.57 megapascals (5000 psig) with controlled amounts of selected contaminants. The data were evaluated to characterize the impact ignition susceptibility of the materials under the test conditions. The test program was performed at the NASA White Sands Test Facility (WSTF) under the direction of D. L. Phippen and J. S. Stradling. This facility operates as part of the NASA Lyndon B. Johnson Space Center.

Apparatus

The tests were performed by dropping a plummet of known weight from a known height onto a striker pin that transmitted impact energy to a test sample

enclosed in a sealed test chamber. Oxygen pressure and sample temperature were controlled to specific test conditions. A drop-weight impact tester (fig. 1) devised by the Army Ballistic Missile Agency (currently the NASA George C. Marshall Space Flight Center) was the basic apparatus used in these tests. For optimum energy transfer, this basic tester was modified to accept a 3.40-kilogram (7.5-lb) plummet in addition to the original 9.07-kilogram (20-lb) plummet. The lighter plummet was used for obtaining impact energies from 21 to 84 J/cm² (100 to 400 ft-lb/in²), and the heavier plummet was used to obtain impact energies from 105 to 252 J/cm² (500 to 1200 ft-lb/in²).

So that the energy transfer efficiency could be established, the plummet rebound height was determined by a rebound-height sensing device. A striker pin with an impact face diameter of 0.0635 centimeter (0.250 in.) was used so that impact energies to 252 J/cm² (1200 ft-lb/in²) could be obtained with the available drop weights and heights. Also, a plummet rebound catch device was installed on the system in order to insure a single mechanical impact.

Two methods of retaining the test sample in the center of the sample cup were used during these tests. For the Teflon and aluminum samples, a sample washer (fig. 2) was initially used. This method of sample centering had been successfully used in other mechanical impact test programs performed at WSTF. However, because aluminum appeared to be sensitive to this configuration, the sample cup was modified by the addition of a shallow centering depression (fig. 3), which eliminated the need for the sample washer. A heater was installed in the chamber anvil nut, as shown in figures 2 and 3, for testing at 533 and 811 K (500° and 1000° F). A thermocouple located in the chamber was calibrated to measure the sample temperature.

Test Logic

The ignition susceptibility of the materials with selected contaminants was characterized in two steps:

- (1) A base line was established by impact testing the samples in each configuration with no contaminant added.

- (2) So that the deviation from the established base line could be characterized, each of the five selected contaminants was applied to the samples, which were then impact tested in each configuration.

The ignition threshold of each sample configuration was established according to the following test sequence:

(1) The impact energy was adjusted initially to the minimum value (21 J/cm²; 100 ft-lb/in²) and then increased for each subsequent test in 21-J/cm² (100-ft-lb/in²) steps until either sample ignition or the maximum available impact energy (252 J/cm²; 1200 ft-lb/in²) was reached. The temperature was held constant for each sample configuration in the energy matrix.

(2) When ignition occurred, the test was repeated at that impact energy at least three times. If four consecutive ignitions were not observed, the impact energy was increased in 21-J/cm² (100-ft-lb/in²) steps until four consecutive ignitions were obtained.

(3) After four consecutive ignitions, the impact energy was decreased in 21-J/cm² (100-ft-lb/in²) steps until no ignitions were observed in four consecutive tests at a particular energy level.

For consistent reporting of reactions, an ignition is defined to have occurred when, upon completion of an impact test, physical observation of the test sample clearly indicated that sample ignition had occurred. Ignition was normally evidenced by complete consumption of the sample, welding of the striker pin to the sample holder, or other evidences of significant heat generation at the impact area. The evidence of aluminum reactions with and without the contaminants is presented photographically in appendix A.

Operating Procedures

Materials Preparation

The Teflon samples were prepared in 0.254, 0.635, and 1.270 centimeter (0.100, 0.250, and 0.500 in.) diameters and 0.0076, 0.0254, and 0.254 centimeter (0.003, 0.010, and 0.100 in.) thicknesses. The test samples were rinsed in deionized water at 322 K (120° F), then blown dry with filtered nitrogen gas, and finally hermetically sealed in polyethylene bags.

The metallic samples were prepared with a diameter of 0.635 centimeter (0.250 in.). The 304 stainless-steel samples tested were 0.635 and 0.0254 centimeter (0.100 and 0.010 in.) thick, and the aluminum samples were 0.3175, 0.1575, and 0.0254 centimeter (0.125, 0.062, and 0.010 in.) thick. The stainless-steel test samples were agitated for 5 minutes in a detergent bath, then rinsed with deionized water at 322 K (120° F), dried with filtered gaseous nitrogen, and finally individually hermetically sealed in polyethylene bags. The 6061-T6 aluminum test samples were precision solvent cleaned according to WSTF surface cleanliness requirements

(level 4, see appendix B for surface cleaning requirements) and then individually hermetically sealed in clean Teflon bags.

Contaminant Application

The following contaminants were used in the tests:

- (1) Rigid brand pipe cutting oil
- (2) ESSO brand SAE 30-weight motor oil
- (3) Crown brand toolmakers dye
- (4) Silicon dioxide sized to 60 micrometers
- (5) Copper powder sized to 60 micrometers

The Teflon test samples were coated, on the surface exposed to the striker pin, with 0.019 milligram of contaminant. The samples were allowed to cure in a controlled environment (desiccator) at ambient conditions for 24 hours and then immediately tested.

Three basic techniques were used for applying the contaminants to the metal samples:

(1) The oil contaminants were introduced to the sample by injecting 0.1 cubic centimeter (0.1 milliliter) of the oil into the Teflon sample bag and thereby soaking the sample in oil.

(2) The toolmakers dye was applied from an aerosol can onto one side of the sample to a thickness of 0.00127 + 0.00061 centimeter (0.0005 + 0.00025 in.) The oil and dye-contaminated samples were allowed to cure for at least 24 hours in a hermetically sealed desiccator.

(3) The grit contaminants were introduced by using a measuring spatula of approximately 0.01 cubic centimeter (0.01 milliliter) to apply the grit to the sample after it had been loaded in the sample cup. The amount of grit by weight was approximately 13 + 2 milligrams (0.37 oz) of silicon dioxide or 22 + 3 milligrams (0.62 oz) of copper.

Testing Procedure

The testing procedure used in the impact tests was as follows:

(1) The striker-pin impact diameter was maintained at 0.635 + 0.005 centimeter (0.250 + 0.002 in.), and the impact surfaces were maintained to approximately an rms 32 finish.

(2) The test chamber and all its components were thoroughly cleaned with Freon and dried with filtered nitrogen gas.

(3) The prepared test sample was then placed in the test chamber with noncontaminating manipulators.

(4) The correct plummet was installed in the drop tower and adjusted to the height required for the desired impact energy.

(5) The chamber pressure and temperature control systems were energized to achieve the proper test pressure and temperature.

(6) The striker pin was pneumatically counter-balanced to maintain mechanical contact with the test sample.

(7) Then the plummet was released and allowed to impact the test sample once.

(8) The sample was removed and examined for evidence of reaction.

(9) The chamber and associated components were cleaned with Freon, and a new test sample was positioned for testing.

The pressures and temperatures at which the materials were tested in the various contaminants are shown in the table on page 4.

Test Results

Teflon

The ignition threshold regions of a number of Teflon-contaminant combinations at 294 and 533 K (70° and 500° F) and 34.57 megapascals (5000 psig) are illustrated in figure 4. Figure 4(a) is for a sample diameter of 0.635 centimeter (0.250 in.) and a thickness of 0.0076 centimeter (0.003 in.); figure 4(b) is for the same sample diameter but a thickness of 0.0254 centimeter (0.010 in.). The data from tests at 34.57 megapascals (5000 psig) are presented in tables I to VI. The data from tests at lower pressures and for diameters to 1.270 centimeters (0.500 in.) are presented in appendix C. The lowest level of each bar in figure 4 represents the highest energy level at which no sample ignitions occurred. The highest level of each bar represents the lowest energy level either where four consecutive ignitions occurred or where the maximum test apparatus capability (252 J/cm²; 1200 ft-lb/in²) was reached. The numbers above the bars represent the number of sample ignitions that occurred in the number of tests made at the peak energy level.

The uncontaminated Teflon did not ignite in the tests to which it was subjected. However, toolmakers dye, motor lubricating oil, and cutting oil caused ignition in the thinner Teflon samples at 294 K (70° F). Raising the temperature to 533 K (500° F) lowered the impact energy required for ignition and narrowed the ignition threshold. Thus all the contaminants caused the thinner Teflon samples to ignite at the higher temperature. The contaminant that caused the greatest change in Teflon ignitibility with temperature was silicon dioxide grit. At 294 K (70° F) this contaminant did not cause ignition; however, at 533 K (500° F) it caused Teflon to ignite at relatively low impact energies.

Copper powder also caused the thinner Teflon samples to ignite only at 533 K (500° F), but at higher impact energies. Changing the test sample diameter had no appreciable effect on impact sensitivity

(tables I to III). Changing the sample thickness produced no conclusive results, although several of the sample-contaminant reactions changed. The thicker Teflon samples ignited with cutting oil, toolmakers dye, and silicon dioxide grit. The thinner samples ignited with the same flammable hydrocarbon contaminants and with motor lubricating oil, but not with silicon dioxide grit. Apparently, the impact energy imparted to the thinner samples was sufficient to ignite the flammable contaminant, and hence the Teflon, even though the thinner samples had limited heat capacity because of their small mass.

The ignition threshold of each contaminant was established by igniting it in gaseous oxygen. The results are presented in table VII. No discernible region of ignition probability could be defined, except for the toolmakers dye, which readily ignited at energies as low as 42 J/cm² (200 ft-lb/in²). Even though the oil and grit ignitions were random in nature, significant test-chamber pressure and temperature increases were observed when ignition did occur.

304 Stainless Steel

The 304-stainless-steel samples were tested at the most extreme environmental conditions available with the equipment, 811 K (1000° F) and 34.57 megapascals (5000 psig). The tests were conducted with controlled amounts of contaminants at impact energies to 252 J/cm² (1200 ft-lb/in²). The test samples were 0.635 centimeter (0.250 in.) in diameter and 0.254 or 0.0254 centimeter (0.100 or 0.010 in.) thick. According to ignition threshold data, presented in table VIII, both uncontaminated and contaminated 304 stainless steel were nonreactive.

6061-T6 Aluminum

The 6061-T6 aluminum test samples were 0.635 centimeter (0.250 in.) in diameter and 0.0250, 0.1575, or 0.3175 centimeter (0.010, 0.062, or 0.125 in.) thick. The ignition threshold regions of each aluminum-contaminant combination at the 34.57-megapascal (5000-psig) test pressure are presented in figures 5 and 6. Figure 5 shows the ignition threshold regions obtained at a test temperature of 294 K (70° F) with the sample-washer configuration. The data for the two retainer configurations (figs. 2 and 3) with the uncontaminated and contaminated samples are presented in tables IX to XIV.

Uncontaminated aluminum samples were initially tested at 294 K (70° F), with the washer used to maintain sample alignment with the striker pin during impact. This configuration produced reactions with the two thicker samples (fig. 5). Several reactions oc-

| Sample material | Contaminant | Sample diameter | | Sample thickness | | Test pressure | | Test temperature | |
|-----------------|--|-----------------|-------|------------------|-------|---------------|------|------------------|---------|
| | | cm | in. | cm | in. | MPa | psig | K | °F |
| Teflon | None | 0.635 | 0.250 | 0.0076 | 0.003 | 0.793 | 100 | 294 | 70 |
| | | ↓ | ↓ | ↓ | ↓ | 6.997 | 1000 | 294 | 70 |
| | | | | | | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .0254 | .010 | .793 | 100 | 294 | 70 |
| | | | | .0254 | .010 | 13.89 | 2000 | 294 | 70 |
| | | | | .0254 | .010 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .254 | .100 | .793 | 100 | 294 | 70 |
| | | | | .254 | .100 | 6.99 | 1000 | 533 | 500 |
| | | | | .254 | .100 | 34.57 | 5000 | 294 | 70 |
| | | .254 | .100 | .254 | .100 | .793 | 100 | 294 | 70 |
| | | 1.270 | .500 | .0076 | .003 | 6.99 | 1000 | 533 | 500 |
| | | 1.270 | .500 | .0076 | .003 | 34.57 | 5000 | 294 | 70 |
| | | 1.270 | .500 | .0254 | .010 | 6.99 | 1000 | 533 | 70 |
| | Cutting oil | 0.635 | 0.250 | 0.0254 | 0.010 | 6.99 | 1000 | 294 | 70 |
| | | .635 | .250 | .0254 | .010 | 34.57 | 5000 | ↓ | ↓ |
| | | .635 | .250 | .254 | .100 | 6.99 | 1000 | ↓ | ↓ |
| | | .254 | .100 | .0254 | .010 | 6.99 | 1000 | ↓ | ↓ |
| | | .635 | .250 | .0076 | .003 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | Motor lubricating oil | 0.635 | 0.250 | 0.0254 | 0.010 | 6.99 | 1000 | 294 | 70 |
| | | | | .0254 | .010 | 34.57 | 5000 | 294 | 70 |
| | | | | .0076 | .003 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .254 | .100 | 34.57 | 5000 | 294 | 70 |
| | Toolmakers dye | 0.635 | 0.250 | 0.0254 | 0.010 | 6.99 | 1000 | 294 | 70 |
| | | | | .0254 | .010 | 34.57 | 5000 | 294 | 70 |
| | | | | .254 | .100 | | | 294 | 70 |
| | | | | .0076 | .003 | ↓ | ↓ | 294, 533 | 70, 500 |
| | | | | .0076 | .003 | ↓ | ↓ | 294 | 70 |
| | Nonignitable grit (silicon dioxide) | 0.635 | 0.250 | 0.0254 | 0.010 | 6.99 | 1000 | 294 | 70 |
| | | | | .0254 | .010 | 34.57 | 5000 | 294 | 70 |
| | | | | .254 | .100 | ↓ | ↓ | 294 | 70 |
| | | | | .0076 | .003 | ↓ | ↓ | 294, 533 | 70, 500 |
| | | | | .0076 | .003 | ↓ | ↓ | 294 | 70 |
| | Ignitable grit (copper powder) | 0.635 | 0.250 | 0.0254 | 0.010 | 6.99 | 1000 | 294 | 70 |
| | | | | .0254 | .010 | 34.57 | 5000 | 294 | 70 |
| | | | | .254 | .100 | 34.57 | 5000 | 294 | 70 |
| | | | | .0076 | .003 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .0254 | .010 | 6.99 | 1000 | 294 | 70 |
| Stainless steel | All | 0.635 | 0.250 | 0.254 | 0.100 | 34.57 | 5000 | 811 | 1000 |
| | | | | .0254 | .010 | 34.57 | 5000 | 811 | 1000 |
| Aluminum | None | 0.635 | 0.250 | 0.0254 | 0.010 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .1575 | .062 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .3175 | .125 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | Motor lubricating oil | 0.635 | 0.250 | 0.0254 | 0.010 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .1575 | .062 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .3175 | .125 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | Toolmakers dye | 0.635 | 0.250 | 0.0254 | 0.010 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .1575 | .062 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .3175 | .125 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | Nonignitable grit (silicon dioxide) | 0.635 | 0.250 | 0.0254 | 0.010 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .1575 | .062 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .3175 | .125 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | Ignitable grit (copper powder) | 0.635 | 0.250 | 0.0254 | 0.010 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .1575 | .062 | 34.57 | 5000 | 294, 533 | 70, 500 |
| | | | | .3175 | .125 | 34.57 | 5000 | 294, 533 | 70, 500 |

curred intermittently during testing of the thickest sample at impact energies from 210 to 231 J/cm² (1000 to 1100 ft-lb/in²). However, this configuration appeared to allow excessive extrusion between the washer and the striker pin. This introduced the possibility that the reactions were caused by heat generated during the extrusion process. The retainer configuration was then changed to the centered sample cup (fig. 3). This configuration produced no reactions with the thinnest and thickest uncontaminated aluminum samples, but a reaction did occur with the 0.1575-centimeter- (0.062-in.-) thick uncontaminated aluminum sample (fig. 6). Although retainer configuration no doubt influenced the results, the sensitivity of aluminum to ignition by single mechanical impact was increased by contamination.

With the liquid contaminants on aluminum, the following test results were obtained:

(1) The reactivity of the thinnest aluminum sample contaminated with motor lubricating oil and cutting oil was significantly increased at 294 K (70° F). Raising the temperature to 533 K (500° F) further increased sensitivity to these contaminants. Toolmakers dye caused the aluminum samples to react at 294 K (70° F); however, no reactions occurred at 533 K (500° F), probably because the higher temperature destroyed the ignition properties of the dye.

(2) The 0.1575-centimeter- (0.062-in.-) thick aluminum samples reacted with these contaminants also; however, it was difficult to discern the contribution of the contaminants since the noncontaminated samples also reacted. The oils caused significantly greater reactivity at 533 K (500° F) since considerably less impact energy was required to obtain reactions severe enough to damage the test chamber.

(3) Sample thicknesses of 0.0254 and 0.1575 centimeter (0.010 and 0.062 in.) gave somewhat conflicting results. When the samples were contaminated with motor lubricating oil, the reactivity remained about the same; but with cutting oil and toolmakers dye, the reactivity decreased. The 0.3175-centimeter (0.125-in.-) thick samples were the least reactive: The motor lubricating oil and cutting oil caused no reactions at 294 K (70° F), but at 533 K (500° F) some reactions did occur. Some of these reactions were severe enough to damage the test chamber. Toolmakers dye caused reactions at 533 K (500° F) in the 0.1575-centimeter- (0.062-in.-) thick samples but not in the 0.3175-centimeter- (0.125-in.-) thick samples.

With the grit contaminants on aluminum, the following results were obtained:

(1) Reactivity increased during some tests of aluminum contaminated with silicon dioxide and copper powder. However, comparing these data to the uncontaminated-aluminum data suggested that reactions with grit contamination could not be con-

clusively determined to be caused by the contaminant. The thinnest aluminum samples were essentially nonreactive in both the sample-washer (fig. 2) and centered-sample-cup configurations (fig. 3). The medium-thick samples were reactive, but more impact energy was required to obtain four reactions out of four tests at 294 K (70° F) than at 533 K (500° F).

(2) The thickest aluminum samples did not react at 294 K (70° F) but did react at 533 K (500° F). Therefore, raising the temperature probably increased the reactivity of aluminum contaminated with either silicon dioxide or copper powder.

(3) Comparing results for the thickest aluminum samples both uncontaminated and contaminated with copper powder in the two retainer configurations (figs. 2 and 3) suggests that the sample-washer restraint could increase reactivity by raising local temperatures as the sample was extruded between the striker pin and the washer. The medium-thick aluminum samples reacted in all the configurations in which they were tested. The cause for the overall reactivity being greater in this thickness is unknown. Again, however, this increased reactivity could have been caused by the mechanical restraint of the centered sample cup, which upon impact caused the sample to extrude between the striker pin and the cup. Typical reactions encountered are shown in appendix A. In a number of reactions, sufficient energy was generated to cause failure of the test chamber.

The average rebound height is plotted as a function of impact energy in figure 7 for the three aluminum sample thicknesses. The rebound height is an average of at least 20 rebounds at each impact energy on each respective thickness of uncontaminated aluminum. The lack of continuity for each sample thickness between 84 and 105 J/cm² (400 and 500 ft-lb/in²) is due to the change in plummet weight at that energy level. No significant deviations in rebound height were observed as a result of the sample reactions. The resolution of the rebound-height sensing devices was +1.27 centimeters (+1/2 in.).

The impact energy (the total potential energy of the plummet) is plotted as a function of the rebound corrected impact energy (the potential energy less the energy required to cause the rebound) in figure 8. From the linearity of the curve for each sample thickness, the energy transfer efficiency of the test system appears to be essentially independent of the plummet drop height. The energy transfer efficiency is approximately 77 percent for the thinnest sample and 83 percent for the two thicker samples. The efficiency factor for the two thicker samples would affect figures 5 and 6 by regradiating the scale to approximately 210 J/cm² (1000 ft-lb/in²) instead of to 252 (1200). The efficiency factor for the thinnest sample would compress the scale by an additional 6 percent.

Conclusions

Uncontaminated Teflon was insensitive to ignition by a single mechanical impact in a high-pressure oxygen environment over the range of impact energies and temperatures applied. Teflon contaminated with toolmakers dye, cutting oil, or lubricating oil did ignite under the test conditions. In many instances, raising the test temperature lowered the impact energy required for ignition and narrowed the threshold regions for ignition. Increasing the thickness of the test samples (from 0.0076 to 0.0254 cm (0.0003 to 0.010 in.)) lowered the impact energy required for ignition with the cutting oil and silicon dioxide contaminants. The 304 stainless steel was insensitive to ignition in the oxygen environment for the contaminants used and over the range of test conditions.

The 6061-T6 aluminum was sensitive to certain retainer configurations. The material appeared to react when no contaminants were added whenever the retainer configuration caused the sample to extrude between the retainer and the striker pin. Contaminating aluminum with cutting oil, lubricating oil, and toolmakers dye increased its sensitivity to mechanical impact in oxygen. Contaminating aluminum with silicon oxides and copper powder did not conclusively affect its sensitivity to mechanical impact.

Additional tests should be performed to define more completely the susceptibility of materials to ignition by mechanical impact in oxygen and to clarify cleanliness requirements for oxygen systems. These tests should include (1) investigation of the mechanisms that cause the ignition of clean aluminum in the mechanical impact tests; (2) mechanical impact tests on aluminum contaminated with other lubricants commonly used in oxygen systems; and (3) mechanical impact tests on other materials used in oxygen systems.

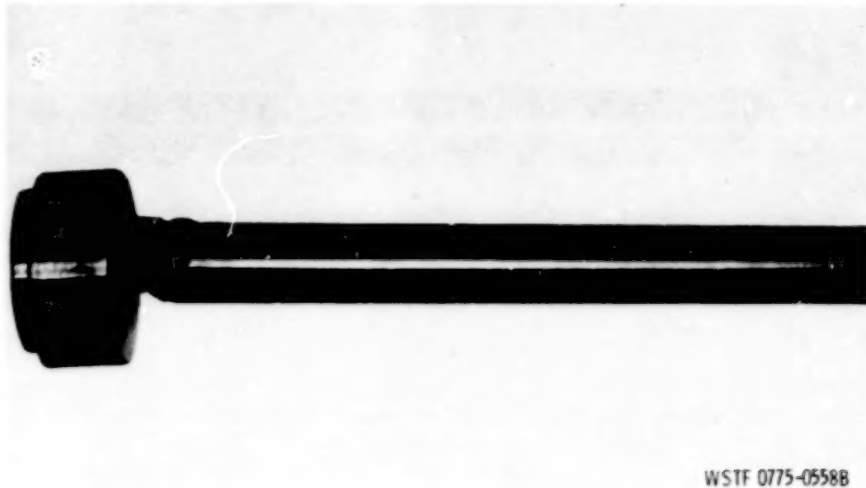
Levis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, July 10, 1979,
505-08.

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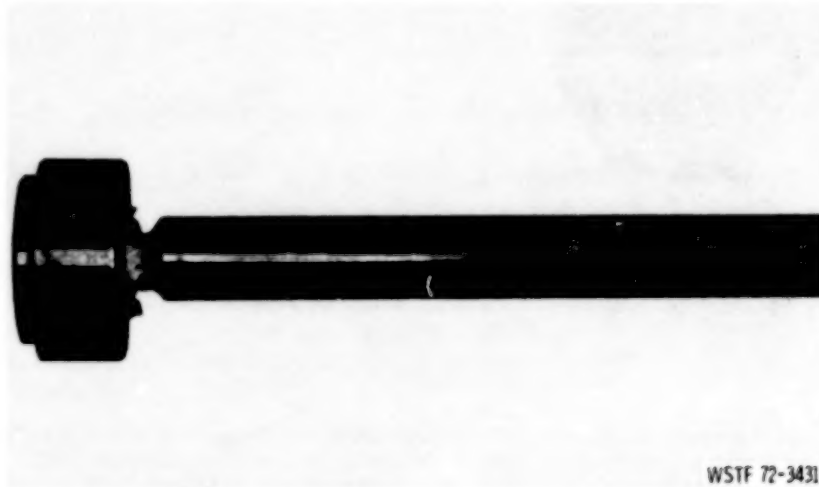
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Appendix A

Typical Reactions of 6061-T6 Aluminum to Mechanical Impact in Gaseous Oxygen Environment



Sample thickness, 0.1575 cm (0.062 in.); sample diameter, 0.635 cm (0.250 in.); contaminant, cutting oil; test pressure, 34.57 MPa (5000 psig); test temperature, 294 K (70° F); impact (drop) energy, 189 J/cm² (900 ft-lb/in²); striker pin diameter, 0.635 cm (0.250 in.).

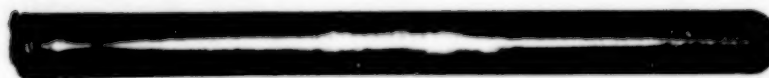
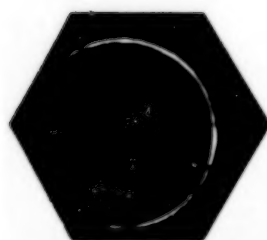


Sample thickness, 0.1575 cm (0.062 in.); sample diameter, 0.635 cm (0.250 in.); contaminant, toolmakers dye; test pressure, 34.57 MPa (5000 psig); test temperature, 294 K (70° F); impact (drop) energy, 168 J/cm² (800 ft-lb/in²); striker pin diameter, 0.635 cm (0.250 in.).



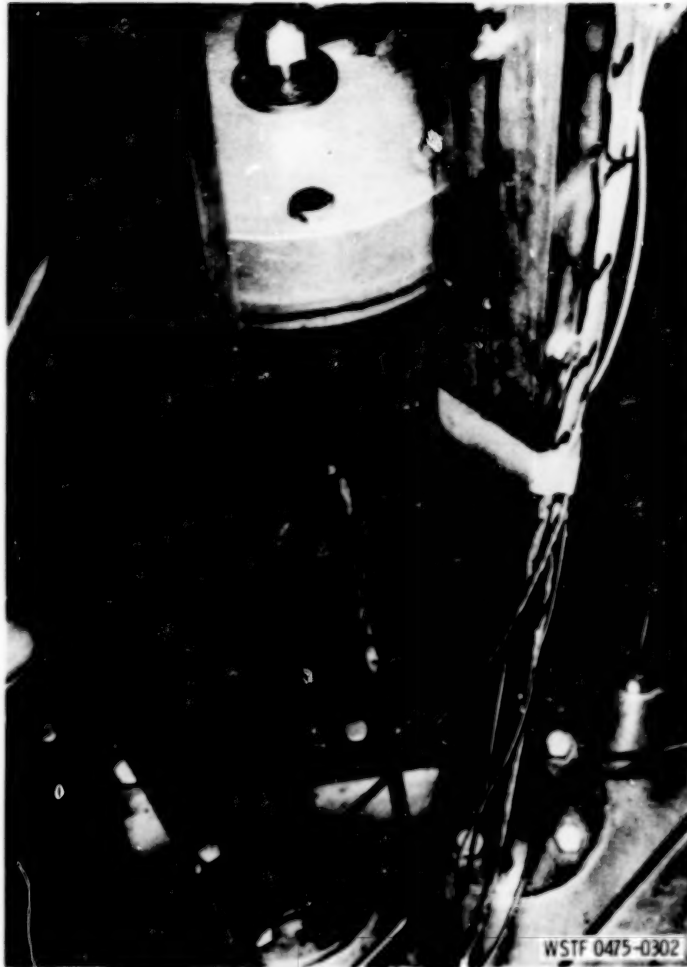
WSTF 0775-0558

Sample thickness, 0.0254 cm (0.010 in.); sample diameter, 0.635 cm (0.250 in.); contaminant, motor lubricating oil; test pressure, 34.57 MPa (5000 psig); test temperature, 294 K (70° F); impact (drop) energy, 84 J/cm² (400 ft-lb/in²); striker pin diameter, 0.635 cm (0.250 in.).



WSTF 0475-0267

Sample thickness, 0.1575 cm (0.062 in.); sample diameter, 0.635 cm (0.250 in.); contaminant, motor lubricating oil; test pressure, 34.57 MPa (5000 psig); test temperature, 294 K (70° F); impact (drop) energy, 168 J/cm² (800 ft-lb/in²); striker pin diameter, 0.635 cm (0.250 in.).



Sample thickness, 0.1575 cm (0.062 in.); contaminant, motor lubricating oil; test pressure, 34.57 MPa (5000 psig); test temperature, 294 K (70° F); impact (drop) energy, 210 J/cm² (1000 ft-lb/in²).

Appendix B

Surface Cleanliness Requirements of White Sands Test Facility

| Level | Normal use of level | Maximum particle distribution of critical surface ^a | | | | Nonvolatile residue of critical surface (maximum quantity), ^a mg | |
|-------|---|--|------------------|---------------------------|------------------|---|--------------------------------------|
| | | Per square meter | | Per square foot | | | |
| | | Size range, μm | Maximum quantity | Size range, μm | Maximum quantity | Per square meter | Per square foot |
| 1 | Test articles, fixtures, or systems requiring a high level of cleanliness (i.e., hydrogen ASRADI fixtures, liquid-oxygen testing fixtures, fuel and oxidizer Hoke sampling bottles, millipore sampling equipment, and chemistry laboratory fluid sampling equipment used for other fluids | 0 - 5 | Unlimited | 0 - 5 | Unlimited | 10 | 1 ↓ |
| | | 6 - 15 | 646 | 6 - 15 | 60 | | |
| | | 16 - 25 | 322 | 16 - 25 | 30 | | |
| | | 26 - 50 | 161 | 26 - 50 | 15 | | |
| | | 51 - 100 | 64 | 51 - 100 | 6 | | |
| | | >100 | 0 | ^b >100 | 0 | | |
| 2 | Facility systems: Fuel (A-50, MMH, N ₂ H ₄ , UDMH) Oxidizer (gaseous and liquid oxygen and N ₂ O ₄) Pressurized gas (gaseous helium and nitrogen and liquid nitrogen) | 0 - 50 | Unlimited | 0 - 50 | Unlimited | 10 | 1 ↓ |
| | | 51 - 175 | 26 910 | 51 - 175 | 2500 | | |
| | | 176 - 350 | 269 | 176 - 350 | 25 | | |
| | | >350 | 0 | ^b >350 | 0 | | |
| | | | | | | | |
| 3 | High- and low-pressure-gaseous-oxygen material test systems | 0 - 10 | Unlimited | 0 - 10 | Unlimited | | d ₂ , e ₃ ↓ |
| | | 11 - 25 | 915 | 11 - 25 | 85 | | |
| | | 26 - 50 | 86 | 26 - 50 | 8 | | |
| | | 51 - 100 | 43 | 51 - 100 | 4 | | |
| | | >100 | 0 | >100 | 0 | | |
| | Fibers | 100 - 175 | 10 | 100 - 175 | 1 | | |
| | | >175 | 0 | >175 | 0 | | |
| | | | | | | | |
| 4 | Gaseous oxygen flash and fire and flammability test chambers | Preclean only | | | | No requirement | |

^aA minimum sample of 100 cm³ (100 milliliters) of test fluid is normally used for each square meter (sq ft) of critical surface area.

^bNo sifting as defined in this document; no count required.

^cFibers counted as particles.

^dBlank total hydrocarbon content.

^eNet total hydrocarbon content.

Appendix C

Results of Single Mechanical Impact Tests at Test Pressures to 6.99 MPa (1000 psig) on Uncontaminated and Contaminated Teflon

| Test temperature | | Sample diameter | | Sample thickness | | Plummet weight | | Impact energy | | Test pressure | | Number of reactions | Number of tests | Rebound height | | Remarks |
|-----------------------|----|-----------------|-------|------------------|-------|----------------|------|-------------------|-----------------------|---------------|------|---------------------|-----------------|----------------|------|--|
| K | °F | cm | in. | cm | in. | kg | lb | J/cm ² | ft-lb/in ² | MPa | psig | | | cm | in. | |
| Uncontaminated Teflon | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.254 | 0.100 | 0.254 | 0.100 | 3.4 | 7.5 | 21 | 100 | 0.79 | 100 | 0 | 4 | 3.8 | 1.5 | No reaction |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | ↓ | 7.6 | 3.0 | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | ↓ | 12.7 | 5.0 | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | ↓ | 15.2 | 6.0 | |
| | | | | | | 9.1 | 20.0 | 105 | 500 | ↓ | ↓ | ↓ | ↓ | 10.2 | 4.0 | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | ↓ | ↓ | 10.2 | 4.0 | |
| | | | | | | ↓ | ↓ | 147 | 700 | ↓ | ↓ | ↓ | ↓ | 12.7 | 5.0 | |
| | | | | | | ↓ | ↓ | 168 | 800 | ↓ | ↓ | ↓ | ↓ | 15.2 | 6.0 | |
| | | | | | | ↓ | ↓ | 189 | 900 | ↓ | ↓ | ↓ | ↓ | 22.9 | 9.0 | |
| | | | | | | ↓ | ↓ | 210 | 1000 | ↓ | ↓ | ↓ | ↓ | 25.4 | 10.0 | |
| | | | | | | ↓ | ↓ | 231 | 1100 | ↓ | ↓ | ↓ | ↓ | 27.9 | 11.0 | |
| | | | | | | ↓ | ↓ | 252 | 1200 | ↓ | ↓ | ↓ | ↓ | 29.2 | 11.5 | |
| | | | | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 0.79 | 100 | 0 | 8 | 2.5 | 1.6 | Significant dimensional change due to impact; no reactions |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | 5 | 7.6 | 3.0 | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | 5 | 7.6 | 3.0 | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | 5 | 13.9 | 5.5 | |
| | | | | | | 9.9 | 20.0 | 105 | 500 | ↓ | ↓ | ↓ | 8 | 10.2 | 4.0 | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | ↓ | 5 | 15.2 | 6.0 | |
| | | | | | | ↓ | ↓ | 147 | 700 | ↓ | ↓ | ↓ | ↓ | 22.9 | 9.0 | |
| | | | | | | ↓ | ↓ | 168 | 800 | ↓ | ↓ | ↓ | ↓ | 25.4 | 10.0 | |
| | | | | | | ↓ | ↓ | 189 | 900 | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | |
| | | | | | | ↓ | ↓ | 210 | 1000 | ↓ | ↓ | ↓ | 8 | ↓ | ↓ | |
| | | | | | | ↓ | ↓ | 231 | 1100 | ↓ | ↓ | ↓ | 5 | ↓ | ↓ | |
| | | | | | | ↓ | ↓ | 252 | 1200 | ↓ | ↓ | ↓ | 8 | ↓ | ↓ | |
| | | 0.635 | 0.250 | 0.0076 | 0.003 | 3.4 | 7.5 | 21 | 100 | 0.79 | 100 | 0 | 8 | 1.3 | 0.5 | No reaction |
| | | | | | | ↓ | ↓ | 42 | 200 | .79 | 100 | ↓ | 5 | 5.1 | 2.0 | |
| | | | | | | ↓ | ↓ | 63 | 300 | .79 | 100 | ↓ | 8 | 8.9 | 3.5 | |
| | | | | | | ↓ | ↓ | 21 | 100 | 6.99 | 1000 | ↓ | 4 | 2.5 | 1.0 | |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | ↓ | 7.6 | 3.0 | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | ↓ | 13.9 | 5.5 | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | ↓ | 19.1 | 7.5 | |
| | | | | | | 9.1 | 20.0 | 105 | 500 | ↓ | ↓ | ↓ | ↓ | 11.4 | 4.5 | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | ↓ | ↓ | 13.9 | 5.5 | |
| | | | | | | ↓ | ↓ | 147 | 700 | ↓ | ↓ | ↓ | ↓ | 16.5 | 6.5 | |
| | | | | | | ↓ | ↓ | 168 | 800 | ↓ | ↓ | ↓ | ↓ | 19.1 | 7.5 | |
| | | | | | | ↓ | ↓ | 189 | 900 | ↓ | ↓ | ↓ | ↓ | 21.6 | 8.5 | |
| | | | | | | ↓ | ↓ | 210 | 1000 | ↓ | ↓ | ↓ | ↓ | 26.7 | 10.5 | |
| | | | | | | ↓ | ↓ | 231 | 1100 | ↓ | ↓ | ↓ | ↓ | 26.7 | 19.5 | |
| | | | | | | ↓ | ↓ | 252 | 1200 | ↓ | ↓ | ↓ | ↓ | 26.7 | 10.5 | |
| | | | | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 0.79 | 100 | 0 | 8 | 1.3 | 0.5 | No reaction |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | 5 | 6.4 | 2.5 | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | 5 | 13.9 | 5.5 | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | 5 | 22.9 | 9.0 | |
| | | | | | | 9.1 | 20.0 | 105 | 500 | ↓ | ↓ | ↓ | 8 | 10.2 | 4.0 | |
| | | | | | | 9.1 | 20.0 | 126 | 600 | ↓ | ↓ | ↓ | 5 | 15.2 | 6.0 | |
| | | | | | | 9.1 | 20.0 | 147 | 700 | ↓ | ↓ | ↓ | 5 | 22.9 | 9.0 | |
| | | | | | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | |

| Test temperature | | Sample diameter | | Sample thickness | | Plummet weight | | Impact energy | | Test pressure | | Number of reactions | Number of tests | Rebound height | | Remarks | |
|--------------------------------------|-----|-----------------|-------|------------------|-------|----------------|------|-------------------|-----------------------|---------------|------|---------------------|-----------------|----------------|------|--|---|
| K | °F | cm | in. | cm | in. | kg | lb | J/cm ² | ft-lb/in ² | MPa | psig | | | cm | in. | | |
| Uncontaminated Teflon (concluded) | | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.635 | 0.250 | 0.0254 | 0.010 | 9.1 | 20.0 | 168 | 800 | 0.79 | 100 | 0 | 5 | 27.9 | 9.0 | No reaction | |
| | | | | | | ↓ | ↓ | 189 | 900 | ↓ | ↓ | ↓ | 5 | ↓ | ↓ | | |
| | | | | | | ↓ | ↓ | 210 | 1000 | ↓ | ↓ | ↓ | 5 | ↓ | ↓ | | |
| | | | | | | ↓ | ↓ | 231 | 1100 | ↓ | ↓ | ↓ | 5 | ↓ | ↓ | | |
| | | | | | | ↓ | ↓ | 252 | 1200 | ↓ | ↓ | ↓ | 5 | 24.1 | 9.5 | | ↓ |
| | | | | | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | | | 0.254 | 0.100 | 3.4 | 7.5 | 21 | 100 | 0.79 | 100 | 0 | 8 | 0 | 0 | No reaction | |
| | | | | | | 3.4 | 7.5 | 42 | 200 | .79 | 100 | 0 | 5 | 1.3 | .5 | | |
| | | | | | | 3.4 | 7.5 | 63 | 300 | .79 | 100 | 0 | 8 | 15.2 | 6.0 | | |
| | | | | | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | |
| | | | | | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | |
| | | | | | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | |
| | | 1.270 | 0.500 | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 1 | 8 | 3.8 | 1.5 | Second test - total burn No reaction | |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | 0 | 5 | 11.4 | 4.5 | | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | 5 | 22.9 | 9.0 | | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | 5 | 22.9 | 9.0 | | |
| | | | | | | 5.1 | 20.0 | 105 | 500 | ↓ | ↓ | ↓ | 8 | 12.7 | 5.0 | | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | ↓ | 5 | 22.9 | 9.0 | | |
| | | | | 0.0076 | 0.003 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 4 | 5.1 | 2.0 | No reaction | |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | ↓ | 10.2 | 4.0 | | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | ↓ | 15.2 | 6.0 | | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | ↓ | 22.9 | 9.0 | | |
| | | | | | | 9.1 | 20.0 | 105 | 500 | ↓ | ↓ | ↓ | ↓ | 8.9 | 3.5 | | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | ↓ | ↓ | 19.1 | 7.5 | | |
| 533 | 500 | 0.635 | 0.250 | 0.254 | 0.100 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 4 | 6.4 | 2.5 | No reaction | |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | ↓ | 6.4 | 2.5 | | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | ↓ | ↓ | 13.9 | 5.5 | | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | ↓ | ↓ | 13.9 | 5.5 | | |
| | | | | | | ↓ | ↓ | 105 | 500 | ↓ | ↓ | ↓ | ↓ | 13.9 | 5.5 | | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | ↓ | ↓ | 19.1 | 7.5 | | |
| | | | | | | ↓ | ↓ | 147 | 700 | ↓ | ↓ | ↓ | ↓ | 15.2 | 6.0 | | |
| | | | | | | ↓ | ↓ | 168 | 800 | ↓ | ↓ | ↓ | ↓ | 27.9 | 11.0 | | |
| | | | | | | ↓ | ↓ | 189 | 900 | ↓ | ↓ | ↓ | ↓ | 25.4 | 10.0 | | |
| | | | | | | ↓ | ↓ | 210 | 1000 | ↓ | ↓ | ↓ | ↓ | 27.9 | 11.0 | | |
| | | | | | | ↓ | ↓ | 231 | 1100 | ↓ | ↓ | ↓ | ↓ | 25.4 | 10.0 | | |
| | | | | | | ↓ | ↓ | 252 | 1200 | ↓ | ↓ | ↓ | ↓ | 25.4 | 10.0 | | |
| Teflon contaminated with cutting oil | | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.635 | 0.250 | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 8 | 3.8 | 1.5 | No reaction Cutting oil ignited; TFE discolored | |
| | | | | | | ↓ | ↓ | 21 | 290 | ↓ | ↓ | 0 | 5 | 11.4 | 4.5 | | |
| | | | | | | ↓ | ↓ | 63 | 300 | ↓ | ↓ | 0 | 5 | 22.9 | 9.0 | | |
| | | | | | | ↓ | ↓ | 84 | 400 | ↓ | ↓ | 2 | 5 | 31.8 | 12.5 | | |
| | | | | | | 9.1 | 20.0 | 105 | 500 | ↓ | ↓ | 2 | 8 | 12.7 | 5.0 | | |
| | | | | | | ↓ | ↓ | 126 | 600 | ↓ | ↓ | 2 | 5 | 22.9 | 9.0 | | |
| | | | | | | ↓ | ↓ | 147 | 700 | ↓ | ↓ | 1 | 5 | 24.1 | 9.5 | | |
| | | | | | | ↓ | ↓ | 168 | 800 | ↓ | ↓ | 2 | 5 | 27.9 | 11.0 | | |
| | | | | | | ↓ | ↓ | 189 | 900 | ↓ | ↓ | 6 | 12 | 27.9 | 11.0 | | |
| | | | | | | ↓ | ↓ | 252 | 1200 | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | |
| | | | | | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | |

| Test temperature | | Sample diameter | | Sample thickness | | Plummet weight | | Impact energy | | Test pressure | | Number of reactions | Number of tests | Rebound height | | Remarks |
|--|----|-----------------|-------|------------------|-------|----------------|------|-------------------|-----------------------|---------------|------|---------------------|-----------------|----------------|------|---|
| K | °F | cm | in. | cm | in. | kg | lb | J/cm ² | ft-lb/in ² | MPa | psig | | | cm | in. | |
| Teflon contaminated with cutting oil (concluded) | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.635 | 0.250 | 0.254 | 0.100 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 8 | 1.3 | 0.5 | No reaction |
| | | | | | | | | 42 | 200 | | | | | 3.8 | 1.5 | |
| | | | | | | | | 63 | 300 | | | | | 7.6 | 3.0 | |
| | | | | | | 9.1 | 20.0 | 84 | 400 | | | | | 11.4 | 4.5 | |
| | | | | | | | | 105 | 500 | | | | | 7.5 | 3.0 | |
| | | | | | | | | 126 | 600 | | | | | 11.4 | 4.5 | |
| | | | | | | ↓ | ↓ | 147 | 700 | | | | | 12.4 | 5.0 | |
| | | | | | | | | 168 | 800 | | | | | 22.9 | 9.0 | |
| | | | | | | | | 189 | 900 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 210 | 1000 | | | 2 | 8 | 25.4 | 10.0 | |
| | | | | | | | | 231 | 1100 | | | 1 | 5 | 33.0 | 13.0 | |
| | | | | | | | | 252 | 1200 | | | 1 | 8 | 33.0 | 13.0 | |
| | | 0.254 | 0.100 | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 8 | 3.8 | 1.5 | Significant dimensional change due to impact; no reaction |
| | | | | | | | | 42 | 200 | | | | | 5.1 | 2.0 | |
| | | | | | | | | 63 | 300 | | | | | 10.2 | 4.0 | |
| | | | | | | 9.1 | 20.0 | 84 | 400 | | | | | 16.5 | 6.5 | |
| | | | | | | | | 105 | 500 | | | | | 7.6 | 3.0 | |
| | | | | | | | | 126 | 600 | | | | | 11.4 | 4.5 | |
| | | | | | | ↓ | ↓ | 147 | 700 | | | | | 11.4 | 4.5 | |
| | | | | | | | | 168 | 800 | | | | | 22.9 | 9.0 | |
| | | | | | | | | 189 | 900 | | | | | 22.9 | 9.0 | |
| | | | | | | | | 210 | 1000 | | | | | 22.9 | 9.0 | |
| | | | | | | | | 231 | 1100 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 252 | 1200 | | | 1 | 8 | 33.0 | 13.0 | |
| Teflon contaminated with motor lubricating oil | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.635 | 0.250 | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 8 | 3.8 | 1.5 | No reaction |
| | | | | | | | | 42 | 200 | | | | | 11.4 | 4.5 | |
| | | | | | | | | 63 | 300 | | | | | 15.2 | 6.0 | |
| | | | | | | 9.1 | 20.0 | 84 | 400 | | | | | 22.9 | 9.0 | |
| | | | | | | | | 105 | 500 | | | | | 12.7 | 5.0 | |
| | | | | | | | | 126 | 600 | | | | | 22.9 | 9.0 | |
| | | | | | | ↓ | ↓ | 147 | 700 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 168 | 800 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 189 | 900 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 210 | 1000 | | | | | 31.8 | 12.5 | |
| | | | | | | | | 231 | 1100 | | | | | 31.8 | 12.5 | |
| | | | | | | | | 252 | 1200 | | | | | 33.0 | 13.0 | |
| Teflon contaminated with toolmakers dye | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.635 | 0.250 | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 3 | 8 | 8.9 | 3.5 | Dye ignited; TFE discolored |
| | | | | | | | | 42 | 200 | | | | | 13.9 | 5.5 | |
| | | | | | | 9.1 | 20.0 | 63 | 300 | | | | | 21.6 | 8.5 | |
| | | | | | | | | 84 | 400 | | | | | 24.1 | 9.5 | |
| | | | | | | | | 105 | 500 | | | | | 13.9 | 5.5 | |
| | | | | | | ↓ | ↓ | 126 | 600 | | | | | 22.9 | 9.0 | |
| | | | | | | | | 147 | 700 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 168 | 800 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 189 | 900 | | | | | 25.4 | 10.0 | |
| | | | | | | | | 210 | 1000 | | | 6 | 8 | 33.0 | 13.0 | |
| | | | | | | ↓ | ↓ | 231 | 1100 | | | 1 | 5 | 33.0 | 13.0 | |
| | | | | | | | | 252 | 1200 | | | 4 | 8 | 33.0 | 13.0 | |

| Test temperature | | Sample diameter | | Sample thickness | | Plummet weight | | Impact energy | | Test pressure | | Number of reactions | Number of tests | Rebound height | | Remarks | | |
|--|----|-----------------|-------|------------------|-------|----------------|------|-------------------|-----------------------|---------------|------|---------------------|-----------------|----------------|-----|-------------|--|--|
| K | °F | cm | in. | cm | in. | kg | lb | J/cm ² | ft-lb/in ² | MPa | psig | | | cm | in. | | | |
| Teflon contaminated with nonignitable grit (silicon dioxide) | | | | | | | | | | | | | | | | | | |
| 294 | 70 | 0.635 | 0.250 | 0.0254 | 0.010 | 3.4 | 7.5 | 21 | 100 | 6.99 | 1000 | 0 | 4 | | | No reaction | | |
| | | | | | | ↓ | ↓ | 42 | 200 | ↓ | ↓ | ↓ | ↓ | | | | | |
| | | | | | | | | 63 | 300 | | | | | | | | | |
| | | | | | | | | 84 | 400 | | | | | | | | | |
| | | | | | | 9.1 | 20.0 | 105 | 500 | | | | | | | | | |
| | | | | | | ↓ | ↓ | 126 | 600 | | | | | | | | | |
| | | | | | | | | 147 | 700 | | | | | | | | | |
| | | | | | | ↓ | ↓ | 168 | 800 | ↓ | ↓ | ↓ | ↓ | | | | | |
| | | | | | | | | 189 | 900 | | | 4 | ↓ | | | | | |
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TABLE I. - IGNITION OF UNCONTAMINATED TEFLON - BY SINGLE MECHANICAL
IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Sample diameter | | Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|-----------------|-------|------------------|-------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| cm | in. | cm | in. | K | °F | | | J/cm ² | ft-lb/in ² |
| 0.635 | 0.250 | 0.0076 | 0.003 | 294 | 70 | 0 | 8 | 252 | 1200 |
| | | .254 | .100 | 294 | 70 | ↓ | 4 | ↓ | ↓ |
| | | .0076 | .003 | 533 | 500 | | 4 | | |
| | | .0254 | .010 | 294 | 70 | | 8 | | |
| | | .0254 | .010 | 533 | 500 | | 4 | | |
| 1.270 | .500 | .0076 | .003 | 533 | 500 | ↓ | 4 | ↓ | ↓ |

TABLE II. - IGNITION OF TEFLON CONTAMINATED WITH MOTOR LUBRICATING
OIL - BY SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Sample diameter | | Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|-----------------|-------|------------------|-------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| cm | in. | cm | in. | K | °F | | | J/cm ² | ft-lb/in ² |
| 0.635 | 0.250 | 0.0076 | 0.003 | 294 | 70 | 1 | 4 | 252 | 1200 |
| | | .0076 | .003 | ↓ | ↓ | 1 | ↓ | 189 | 900 |
| | | .0254 | .010 | | | 0 | | 252 | 1200 |
| | | .254 | .100 | | | 1 | | 210 | 1000 |
| | | .254 | .100 | | | 1 | | 231 | 1100 |
| | | .254 | .100 | | | 1 | | 252 | 1200 |
| 1.270 | .500 | .0076 | .003 | ↓ | ↓ | 0 | | 252 | 1200 |
| | | ↓ | ↓ | 533 | 500 | 1 | | 42 | 200 |
| | | | | ↓ | ↓ | 1 | | 84 | 400 |
| | | | | | | 1 | | 105 | 500 |
| | | | | | | 3 | | 126 | 600 |
| | | | | ↓ | ↓ | 4 | ↓ | 147 | 700 |

TABLE III. - IGNITION OF TEFLON CONTAMINATED WITH CUTTING OIL - BY SINGLE
MECHANICAL IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Sample diameter | | Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|-----------------|-------|------------------|-------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| cm | in. | cm | in. | K | °F | | | J/cm ² | ft-lb/in ² |
| 0.635 | 0.250 | 0.0076 | 0.003 | 294 | 70 | 1 | 4 | 231 | 1000 |
| | | .0076 | .003 | ↓ | ↓ | 2 | ↓ | 252 | 1200 |
| | | .0254 | .010 | ↓ | ↓ | 1 | ↓ | 42 | 200 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 2 | ↓ | 84 | 400 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 105 | 500 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 126 | 600 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 147 | 700 |
| | | ↓ | ↓ | ↓ | ↓ | 2 | ↓ | 168 | 800 |
| | | ↓ | ↓ | ↓ | ↓ | 2 | ↓ | 189 | 900 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 231 | 1000 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 84 | 400 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 105 | 500 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 126 | 600 |
| 1.270 | .500 | .0076 | .003 | ↓ | ↓ | 0 | ↓ | 252 | 1200 |
| .635 | .250 | ↓ | ↓ | 533 | 500 | 3 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 84 | 400 |
| | | ↓ | ↓ | ↓ | ↓ | 3 | ↓ | 105 | 500 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 126 | 600 |

TABLE IV. - IGNITION OF TEFLON CONTAMINATED WITH TOOLMAKERS DYE - BY
SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Sample diameter | | Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|--------------------|--------------------|------------------|-------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| cm | in. | cm | in. | | | | | J/cm ² | ft-lb/in ² |
| | | | | K | °F | | | | |
| ^a 0.635 | ^a 0.250 | 0.0076 | 0.003 | 294 | 70 | 4 | 4 | 126 | 600 |
| | | .0254 | .010 | ↓ | ↓ | 1 | ↓ | 63 | 300 |
| | | .0254 | .010 | ↓ | ↓ | 4 | ↓ | 84 | 400 |
| | | .254 | .100 | ↓ | ↓ | 1 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 3 | ↓ | 84 | 400 |
| | | ↓ | ↓ | ↓ | ↓ | 3 | ↓ | 105 | 500 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 126 | 600 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 84 | 400 |
| | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| ^b .635 | ^b .250 | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 84 | 400 |
| ^a 1.270 | ^a .500 | .0076 | .003 | ↓ | ↓ | 3 | ↓ | 84 | 400 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 105 | 500 |
| ^a .635 | ^a .250 | ↓ | ↓ | 533 | 500 | 3 | ↓ | 21 | 100 |
| | | ↓ | ↓ | ↓ | ↓ | 2 | ↓ | 42 | 200 |
| | | ↓ | ↓ | ↓ | ↓ | 3 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 84 | 400 |

^aDye on one side only.

^bDye on both sides.

TABLE V. - IGNITION OF TEFLON CONTAMINATED WITH NONIGNITIBLE GRIT
(SILICON DIOXIDE) - BY SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Sample diameter | | Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|-----------------|-------|------------------|-------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| cm | in. | cm | in. | K | °F | | | J/cm ² | ft-lb/in ² |
| 0.635 | 0.250 | 0.0076 | 0.003 | 294 | 70 | 0 | 4 | 252 | 1200 |
| | | .025 | .010 | ↓ | ↓ | 0 | ↓ | 21 | 100 |
| | | ↓ | ↓ | ↓ | ↓ | 1 | ↓ | 42 | 200 |
| | | ↓ | ↓ | ↓ | ↓ | 3 | ↓ | 63 | 300 |
| | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 84 | 400 |
| | | .254 | .100 | ↓ | ↓ | 0 | ↓ | 42 | 200 |
| | | .254 | .100 | ↓ | ↓ | 4 | ↓ | 63 | 300 |
| 1.270 | .500 | .0076 | .003 | ↓ | ↓ | 0 | ↓ | 21 | 100 |
| 1.270 | | ↓ | ↓ | ↓ | ↓ | 4 | ↓ | 42 | 200 |
| .635 | .250 | ↓ | ↓ | 533 | 500 | 0 | ↓ | 42 | 200 |
| .635 | | ↓ | ↓ | 533 | 500 | 4 | ↓ | 63 | 300 |

TABLE VI. - IGNITION OF TEFLON CONTAMINATED WITH IGNITIBLE GRIT (COPPER POWDER) - BY SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Sample diameter | | Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|-----------------|-------|------------------|-------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| cm | in. | cm | in. | K | °F | | | J/cm ² | ft-lb/in ² |
| 0.635 | 0.250 | 0.0076 | 0.003 | 294 | 70 | 0 | 4 | 252 | 1200 |
| | | .0254 | .010 | ↓ | ↓ | ↓ | ↓ | 252 | 1200 |
| | | .254 | .100 | ↓ | ↓ | ↓ | ↓ | 252 | 1200 |
| | | .0076 | .003 | 533 | 500 | ↓ | ↓ | 189 | 900 |
| | | .0076 | .003 | 533 | 500 | 3 | ↓ | 210 | 1000 |
| | | .0076 | .003 | 533 | 500 | 4 | ↓ | 231 | 1100 |
| | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| .254 | .100 | .0254 | .010 | 294 | 70 | 0 | ↓ | 252 | 1200 |

TABLE VII. - IGNITION OF CONTAMINANTS BY SINGLE MECHANICAL

IMPACT IN GASEOUS OXYGEN

[Test pressure, 34.57 MPa (5000 psig).]

| Contaminant | Contaminant quantity, mg | Test temperature | | Number of ignitions | Number of tests | Impact energy | |
|-------------------------------------|--------------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|
| | | K | °F | | | J/cm ² | ft-lb/in ² |
| Cutting oil | 0.019 | 294 | 70 | 2 | 4 | 252 | 1200 |
| | | 533 | 500 | 0 | | 252 | 1200 |
| Motor oil | ↓ | 294 | 70 | 2 | | 189 | 900 |
| | | ↓ | ↓ | 2 | | 210 | 1000 |
| | | ↓ | ↓ | 3 | | 231 | 1100 |
| | | ↓ | ↓ | 0 | | 252 | 1200 |
| | | 533 | 500 | 0 | | 189 | 900 |
| | | ↓ | ↓ | 1 | | 210 | 1000 |
| | | ↓ | ↓ | 3 | | 231 | 1100 |
| | | ↓ | ↓ | 0 | | 252 | 1200 |
| Toolmakers dye | 2.100 | 294 | 70 | 1 | ↓ | 42 | 200 |
| | 2.100 | 294 | 70 | 4 | ↓ | 84 | 400 |
| | 2.100 | 533 | 500 | 1 | 1 | 21 | 100 |
| Copper powder (ignitable grit) | .027 | 294 | 70 | 0 | 4 | 252 | 1200 |
| | .027 | 533 | 500 | ↓ | ↓ | 252 | 1200 |
| Silicon dioxide (nonignitable grit) | .012 | 294 | 70 | ↓ | ↓ | 252 | 1200 |
| | .012 | 533 | 500 | ↓ | ↓ | 252 | 1200 |

TABLE VIII. - IGNITION OF 304 STAINLESS STEEL BY SINGLE
MECHANICAL IMPACT IN GASEOUS OXYGEN - CENTER-
SAMPLE CUP CONFIGURATION

Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa
(5000 psig); impact energy, 252 J/cm² (1200 ft-lb/in²).

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Contaminant |
|------------------|-------|------------------|------|---------------------|-----------------|----------------------|
| cm | in. | K | °F | | | |
| 0.254 | 0.100 | 811 | 1000 | 0 | 4 | None |
| | | 811 | 1000 | ↓ | ↓ | Silicon dioxide grit |
| | | 811 | 1000 | ↓ | ↓ | Copper powder |
| .0254 | .010 | 533 | 500 | ↓ | ↓ | Lubricating oil |
| .0254 | .010 | 811 | 1000 | ↓ | ↓ | Lubricating oil |
| .254 | .100 | ↓ | ↓ | ↓ | ↓ | Lubricating oil |
| .0254 | .010 | ↓ | ↓ | ↓ | ↓ | Cutting oil |
| .254 | .100 | ↓ | ↓ | ↓ | ↓ | Cutting oil |
| .254 | .100 | ↓ | ↓ | ↓ | ↓ | Toolmakers dye |

TABLE IX. - IGNITION OF UNCONTAMINATED 6061-T6 ALUMINUM BY SINGLE
MECHANICAL IMPACT IN GASEOUS OXYGEN

[Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).]

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | | Figure ^a |
|---------------------|--------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|---------------------|
| cm | in. | K | °F | | | J/cm ² | ft-lb/in ² | |
| ^b 0.0254 | ^b 0.010 | 294 | 70 | 0 | 4 | 252 | 1200 | 2 |
| .0254 | .010 | 294 | 70 | ↓ | ↓ | 252 | 1200 | 3 |
| .0254 | .010 | 533 | 500 | ↓ | ↓ | 252 | 1200 | 3 |
| .1575 | .062 | 294 | 70 | ↓ | ↓ | 189 | 900 | 2 |
| | | ↓ | ↓ | 1 | ↓ | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 4 | 8 | 252 | 1200 | ↓ |
| | | ↓ | ↓ | 0 | 4 | 168 | 800 | 3 |
| | | ↓ | ↓ | 4 | ↓ | 189 | 900 | ↓ |
| | | 533 | 500 | 0 | ↓ | 147 | 700 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 168 | 800 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 189 | 900 | ↓ |
| | | ↓ | ↓ | 4 | ↓ | 210 | 1000 | ↓ |
| .3175 | .125 | 294 | 70 | 0 | ↓ | 189 | 900 | 2 |
| | | ↓ | ↓ | 1 | ↓ | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 0 | 7 | 252 | 1200 | ↓ |
| | | ↓ | ↓ | ↓ | 4 | 210 | 1000 | 3 |
| | | ↓ | ↓ | ↓ | ↓ | 231 | 1100 | ↓ |
| | | ↓ | ↓ | ↓ | ↓ | 252 | 1200 | ↓ |
| | | 533 | 500 | ↓ | ↓ | 252 | 1200 | ↓ |

^aTest configuration: fig. 2 - sample washer; fig. 3 - centered sample cup.

^bMachined test samples.

TABLE X. - IGNITION OF 6061-T6 ALUMINUM CONTAMINATED WITH MOTOR LUBRICATING OIL - BY SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).]

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | | Figure ^a |
|---------------------|--------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|---------------------|
| cm | in. | K | °F | | | J/cm ² | ft-lb/in ² | |
| ^b 0.0254 | ^b 0.010 | 294 | 70 | 0 | 4 | 21 | 100 | 2 |
| .0254 | .010 | ↓ | ↓ | 1 | ↓ | 42 | 200 | ↓ |
| | | | | 3 | | 63 | 300 | |
| | | | | 4 | | 84 | 400 | |
| | | | | 0 | | 63 | 300 | |
| | | | | 4 | | 84 | 400 | ↓ |
| | | | | 0 | | 126 | 600 | 3 |
| | | | | 1 | | 147 | 700 | ↓ |
| | | | | 4 | | 168 | 800 | |
| | | 533 | 500 | 0 | | 105 | 500 | |
| | | 533 | 500 | 1 | | 126 | 600 | ↓ |
| | | 533 | 500 | 4 | | 147 | 700 | ↓ |
| .1575 | .062 | 294 | 70 | 0 | | 147 | 700 | 2 |
| | | ↓ | ↓ | 1 | | 168 | 800 | ↓ |
| | | ↓ | ↓ | 1 | | 189 | 900 | ↓ |
| | | ↓ | ↓ | 4 | | 210 | 1000 | ↓ |
| ^c .1575 | ^c .062 | 533 | 500 | 0 | | 63 | 300 | 3 |
| | | ↓ | ↓ | 1 | | 84 | 400 | ↓ |
| | | ↓ | ↓ | 3 | | 105 | 500 | ↓ |
| | | ↓ | ↓ | | 3 | 126 | 600 | ↓ |
| | | | | | | 147 | 700 | ↓ |
| .3175 | .125 | 294 | 70 | ↓ | 4 | 252 | 1200 | 2 |
| | | 294 | 70 | 1 | ↓ | 231 | 1100 | 2 |
| ^c .3175 | ^c .125 | 533 | 500 | 0 | ↓ | 147 | 700 | 3 |
| .3175 | .125 | 533 | 500 | 1 | ↓ | 168 | 800 | 3 |
| | | 533 | 500 | 2 | 2 | 189 | 900 | 3 |

^aTest configuration: fig. 2 - sample washer; fig. 3 - centered sample cup.

^bMachined test samples.

^cTest discontinued due to excessive reaction damage to chamber.

TABLE XI. - IGNITION OF 6061-T6 ALUMINUM CONTAMINATED WITH CUTTING

OIL - BY SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).]

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | | Figure ^a |
|---------------------|--------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|---------------------|
| cm | in. | K | °F | | | J/cm ² | ft-lb/in ² | |
| ^b 0.0254 | ^b 0.010 | 294 | 70 | 0 | 4 | 42 | 299 | 2 |
| | | ↓ | ↓ | 1 | ↓ | 63 | 300 | 2 |
| | | ↓ | ↓ | 4 | ↓ | 84 | 400 | 2 |
| | | ↓ | ↓ | 0 | ↓ | 63 | 300 | 3 |
| | | ↓ | ↓ | 4 | ↓ | 84 | 400 | ↓ |
| | | 533 | 500 | 0 | ↓ | 42 | 200 | ↓ |
| | | 553 | 500 | 4 | ↓ | 63 | 300 | ↓ |
| | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| .1575 | .062 | 294 | 70 | 0 | ↓ | 147 | 700 | 2 |
| | | ↓ | ↓ | 1 | 5 | 168 | 800 | ↓ |
| | | ↓ | ↓ | 4 | 4 | 189 | 900 | ↓ |
| | | ↓ | ↓ | 0 | ↓ | 252 | 1200 | ↓ |
| | | 533 | 500 | 1 | ↓ | 105 | 500 | 3 |
| | | 533 | 500 | 1 | ↓ | 126 | 600 | 3 |
| | | 533 | 500 | 4 | ↓ | 147 | 700 | 3 |
| | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| .3175 | .125 | 294 | 70 | 0 | ↓ | 252 | 1200 | 2 |
| | | 533 | 500 | 0 | ↓ | 252 | 1200 | 3 |

^aTest configuration: fig. 2 - sample washer; fig. 3 - centered sample cup.^bMachined test samples.

TABLE XII. - IGNITION OF 6061-T6 ALUMINUM CONTAMINATED WITH TOOL-
MAKERS DYE - BY SINGLE MECHANICAL IMPACT IN GASEOUS OXYGEN

[Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).]

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | | Figure ^a |
|---------------------|----------------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|---------------------|
| cm | in. | K | °F | | | J/cm ² | ft-lb/in ² | |
| ^b 0.0254 | ^b 0.010 .010 | 294 | 70 | 0 | 4 | 63 | 300 | 2 |
| | | ↓ | ↓ | 4 | ↓ | 84 | 400 | ↓ |
| | | ↓ | ↓ | 0 | ↓ | 63 | 300 | ↓ |
| | | ↓ | ↓ | 4 | ↓ | 84 | 400 | ↓ |
| | | ↓ | ↓ | 0 | ↓ | 105 | 500 | 3 |
| | | ↓ | ↓ | 0 | 1 | 126 | 600 | ↓ |
| | | ↓ | ↓ | 0 | 1 | 147 | 700 | ↓ |
| | | ↓ | ↓ | 2 | 4 | 168 | 800 | ↓ |
| | | ↓ | ↓ | 0 | 1 | 189 | 900 | ↓ |
| | | ↓ | ↓ | 0 | 1 | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 0 | 1 | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 2 | 3 | 252 | 1200 | ↓ |
| | | ↓ | ↓ | 0 | 4 | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 0 | 1 | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 4 | 4 | 252 | 1200 | ↓ |
| | | 533 | 500 | 0 | ↓ | 252 | 1200 | ↓ |
| .1575 | .062 | 294 | 70 | 0 | ↓ | 147 | 700 | ↓ |
| | | ↓ | ↓ | 4 | ↓ | 168 | 800 | ↓ |
| | | 533 | 500 | 0 | ↓ | 105 | 500 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 126 | 600 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 147 | 700 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 168 | 800 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 189 | 900 | ↓ |
| | | ↓ | ↓ | 4 | ↓ | 210 | 1000 | ↓ |
| .3175 | .125 | 294 | 70 | 9 | ↓ | 252 | 1200 | 2 |
| | | 533 | 500 | 0 | ↓ | 252 | 1200 | 3 |

^aTest configuration: fig. 2 - sample washer; fig. 3 - centered sample cup.

^bMachined test samples.

TABLE XIII. - IGNITION OF 6061-T6 ALUMINUM CONTAMINATED WITH
NONIGNITIBLE GRIT (SILICON DIOXIDE) - BY SINGLE
MECHANICAL IMPACT IN GASEOUS OXYGEN

[Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psia).]

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | | Figure ^a |
|---------------------|--------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|---------------------|
| cm | in. | K | °F | | | J/cm ² | ft-lb/in ² | |
| ^b 0.0254 | ^b 0.010 | 294 | 70 | 0 | 4 | 252 | 1200 | 2 |
| | | 294 | 70 | 0 | ↓ | 231 | 1100 | 3 |
| | | 294 | 70 | 1 | ↓ | 252 | 1200 | ↓ |
| | | 533 | 500 | 0 | ↓ | 252 | 1200 | ↓ |
| .1575 | .062 | 294 | 70 | 0 | ↓ | 168 | 800 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 189 | 900 | ↓ |
| | | ↓ | ↓ | 1 | 5 | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 4 | 4 | 231 | 1100 | ↓ |
| | | 533 | 500 | 0 | ↓ | 168 | 800 | ↓ |
| | | 533 | 500 | 4 | ↓ | 189 | 900 | ↓ |
| .3175 | .125 | 294 | 70 | 0 | ↓ | 252 | 1200 | 2 |
| | | 533 | 500 | 0 | ↓ | 147 | 700 | 3 |
| | | ↓ | ↓ | 1 | ↓ | 168 | 800 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 189 | 900 | ↓ |
| | | ↓ | ↓ | 4 | ↓ | 210 | 1000 | ↓ |

^aTest configuration: fig. 2 - sample washer; fig. 3 - centered sample cup.

^bMachined test samples.

TABLE XIV. - IGNITION OF 6061-T6 ALUMINUM CONTAMINATED WITH
IGNITIBLE GRIT (COPPER POWDER) - BY SINGLE MECHANICAL
IMPACT IN GASEOUS OXYGEN

[Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).]

| Sample thickness | | Test temperature | | Number of ignitions | Number of tests | Impact energy | | Figure ^a |
|---------------------|--------------------|------------------|-----|---------------------|-----------------|-------------------|-----------------------|---------------------|
| cm | in. | K | °F | | | J/cm ² | ft-lb/in ² | |
| ^b 0.0254 | ^b 0.010 | 294 | 70 | 0 | 4 | 252 | 1200 | 2 |
| .0254 | .010 | 294 | 70 | ↓ | ↓ | 252 | 1200 | 3 |
| | | 533 | 500 | ↓ | ↓ | 252 | 1200 | ↓ |
| 0.1575 | .062 | 294 | 70 | ↓ | ↓ | 168 | 800 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 189 | 900 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 4 | ↓ | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 0 | ↓ | 189 | 900 | 2 |
| | | ↓ | ↓ | 1 | ↓ | 210 | 1000 | ↓ |
| | | ↓ | ↓ | 0 | ↓ | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 2 | ↓ | 252 | 1200 | ↓ |
| | | 533 | 500 | 0 | ↓ | 147 | 700 | 3 |
| | | 533 | 500 | 1 | ↓ | 168 | 800 | ↓ |
| | | 533 | 500 | 4 | ↓ | 189 | 900 | ↓ |
| .3175 | .125 | 294 | 70 | 9 | ↓ | 252 | 1200 | ↓ |
| | | 533 | 500 | 0 | ↓ | 189 | 900 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 210 | 1100 | ↓ |
| | | ↓ | ↓ | 0 | ↓ | 231 | 1100 | ↓ |
| | | ↓ | ↓ | 1 | ↓ | 252 | 1200 | ↓ |

^aTest configuration: fig. 2 - sample washer; fig. 3 - centered sample cup.

^bMachined test samples.

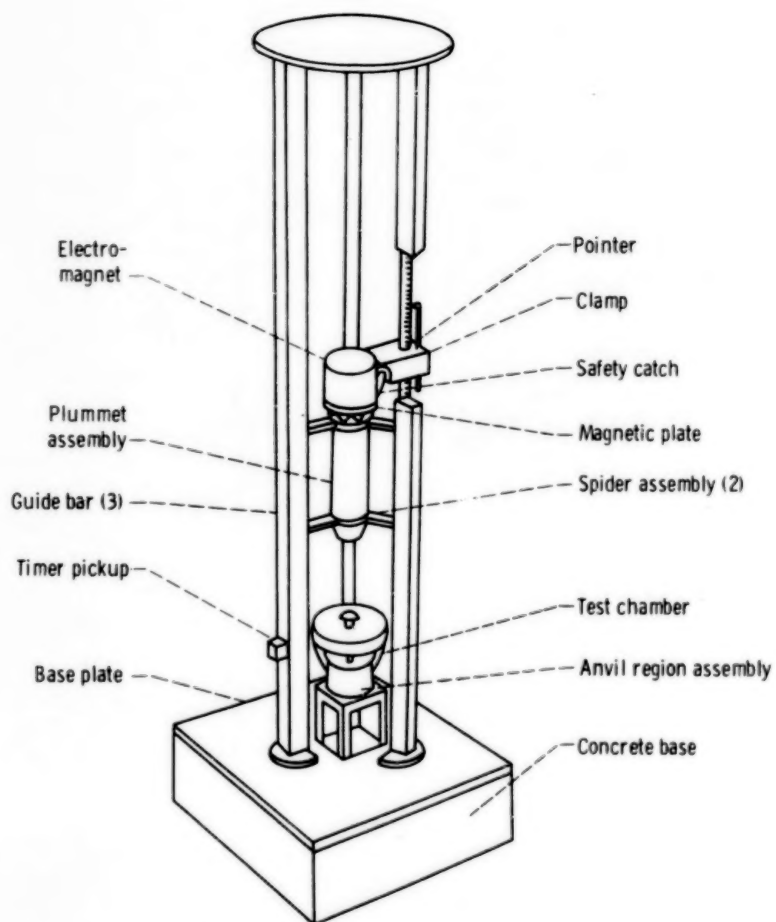


Figure 1. - White Sands test facility mechanical impact test chamber installed on basic Army Ballistic Missile Agency tester.

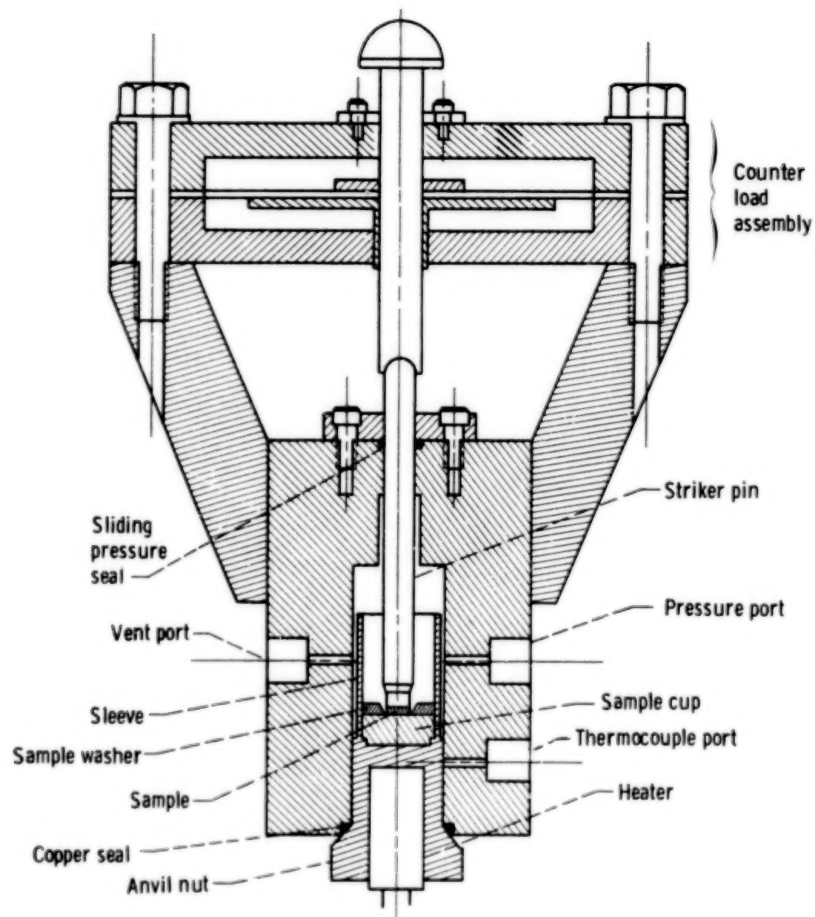


Figure 2. - White Sands Test Facility mechanical impact test chamber - sample-washer configuration. Dimensions of sample washer: outside diameter, 2.281 cm (0.898 in.); inside diameter at 45°, 0.660 cm (0.260 in.); thickness, 0.254 cm (0.100 in.).

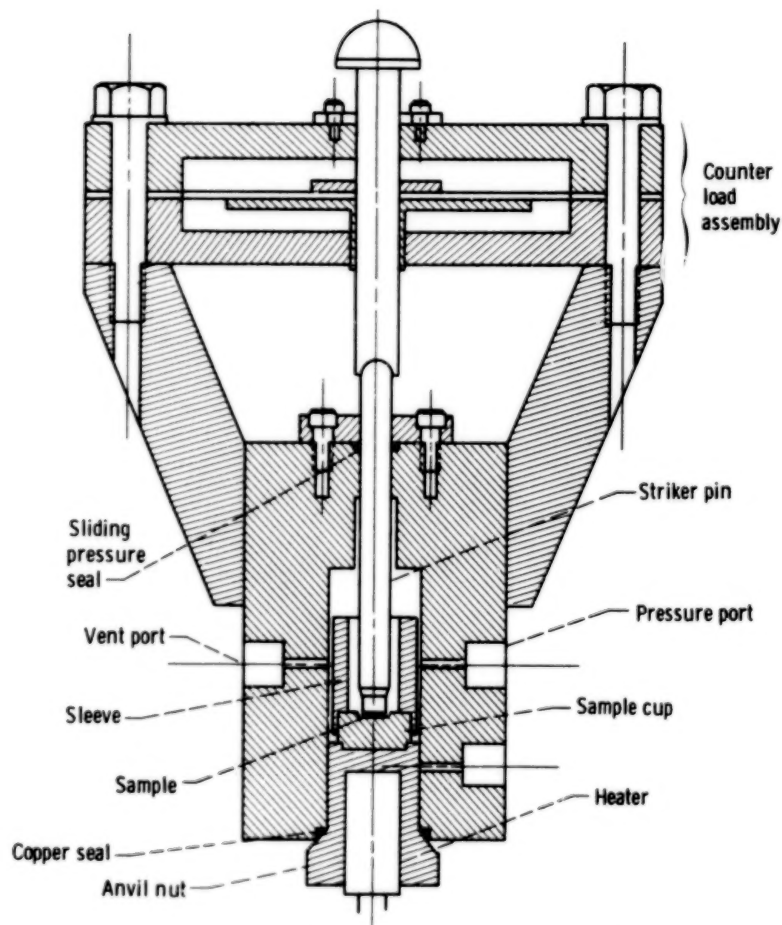
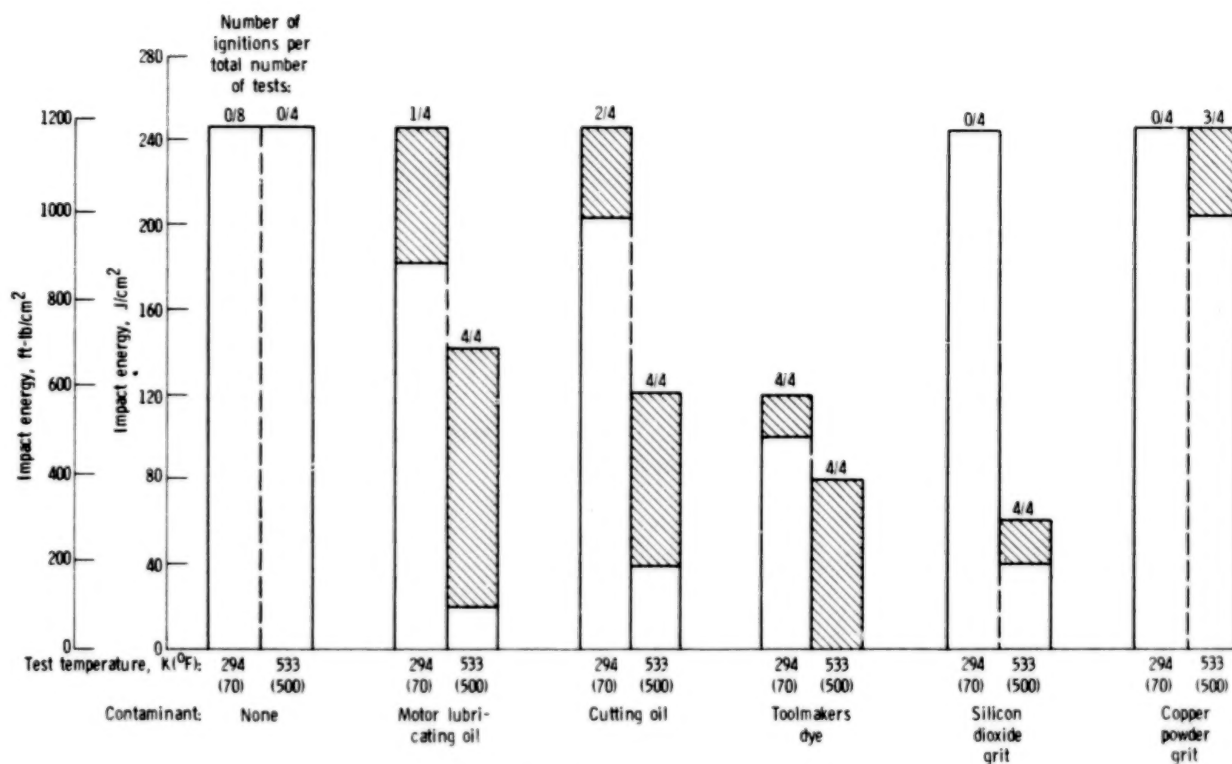
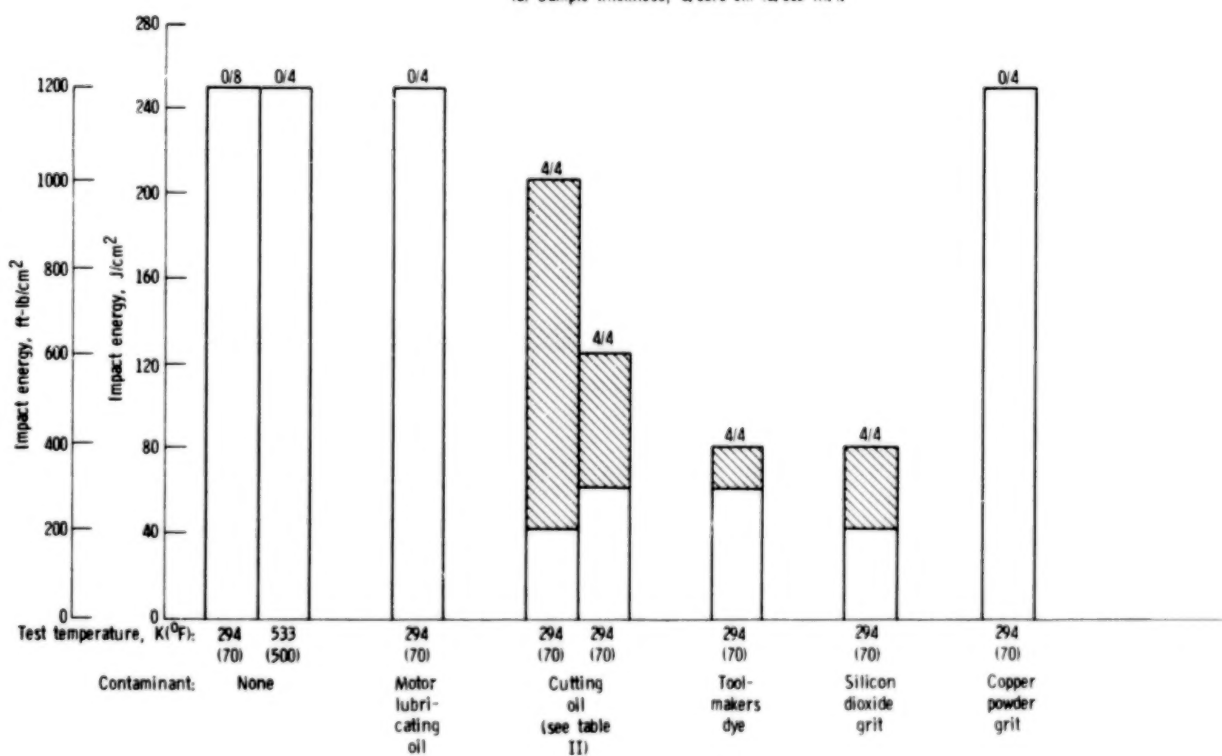


Figure 3. - White Sands Test Facility mechanical impact test chamber - centered-sample-cup configuration. Dimensions of centered sample cup: outside diameter, 2.281 cm (0.898 in.); inside diameter at 45° , 0.660 cm (0.260 in.); depth, 0.038 cm (0.015 in.).



(a) Sample thickness, 0.0076 cm (0.003 in.).



(b) Sample thickness, 0.0254 cm (0.010 in.).

Figure 4 - Mechanical impact ignition threshold regions for Teflon. Sample diameter, 0.635 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).

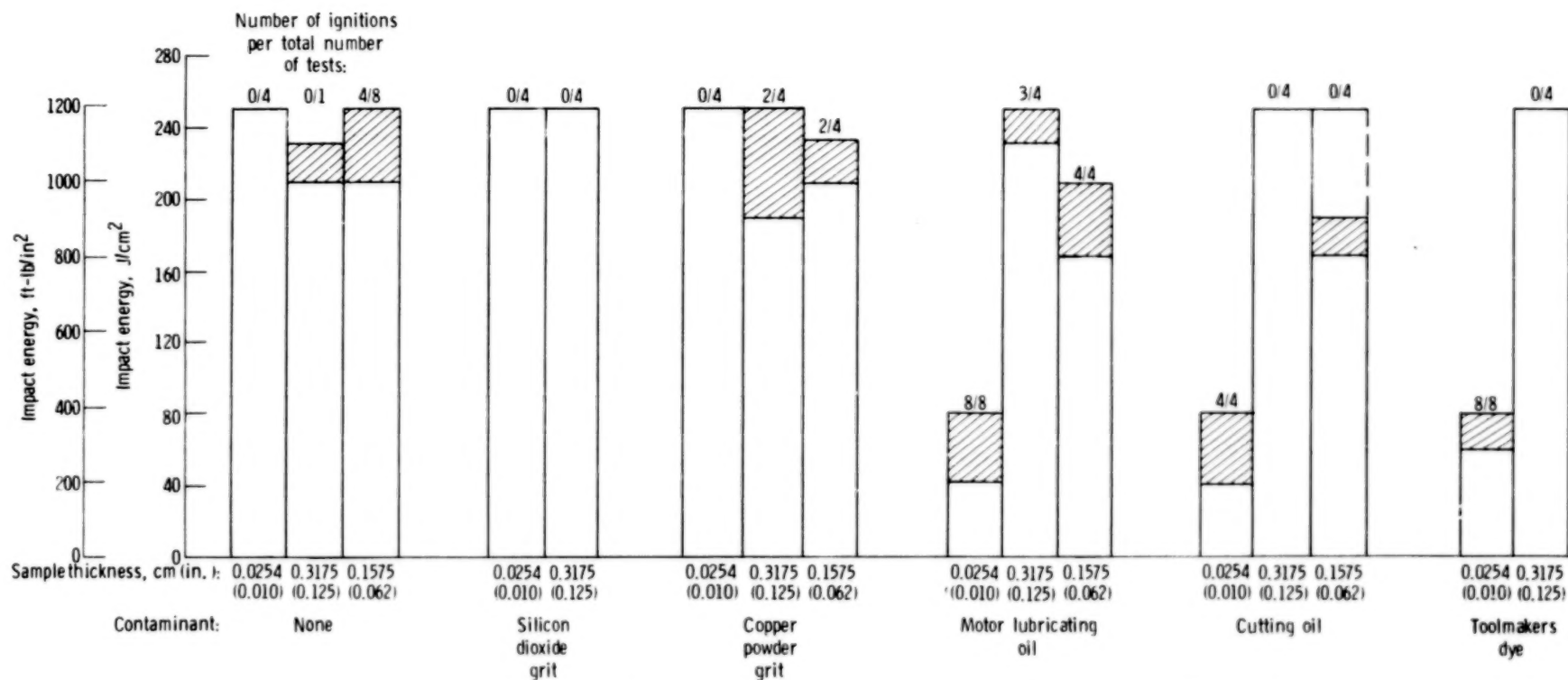


Figure 5. - Mechanical impact ignition threshold regions for 6061-T6 aluminum in sample-washer configuration. Sample diameter, 0.625 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig); test temperature, 294 K (70° F).

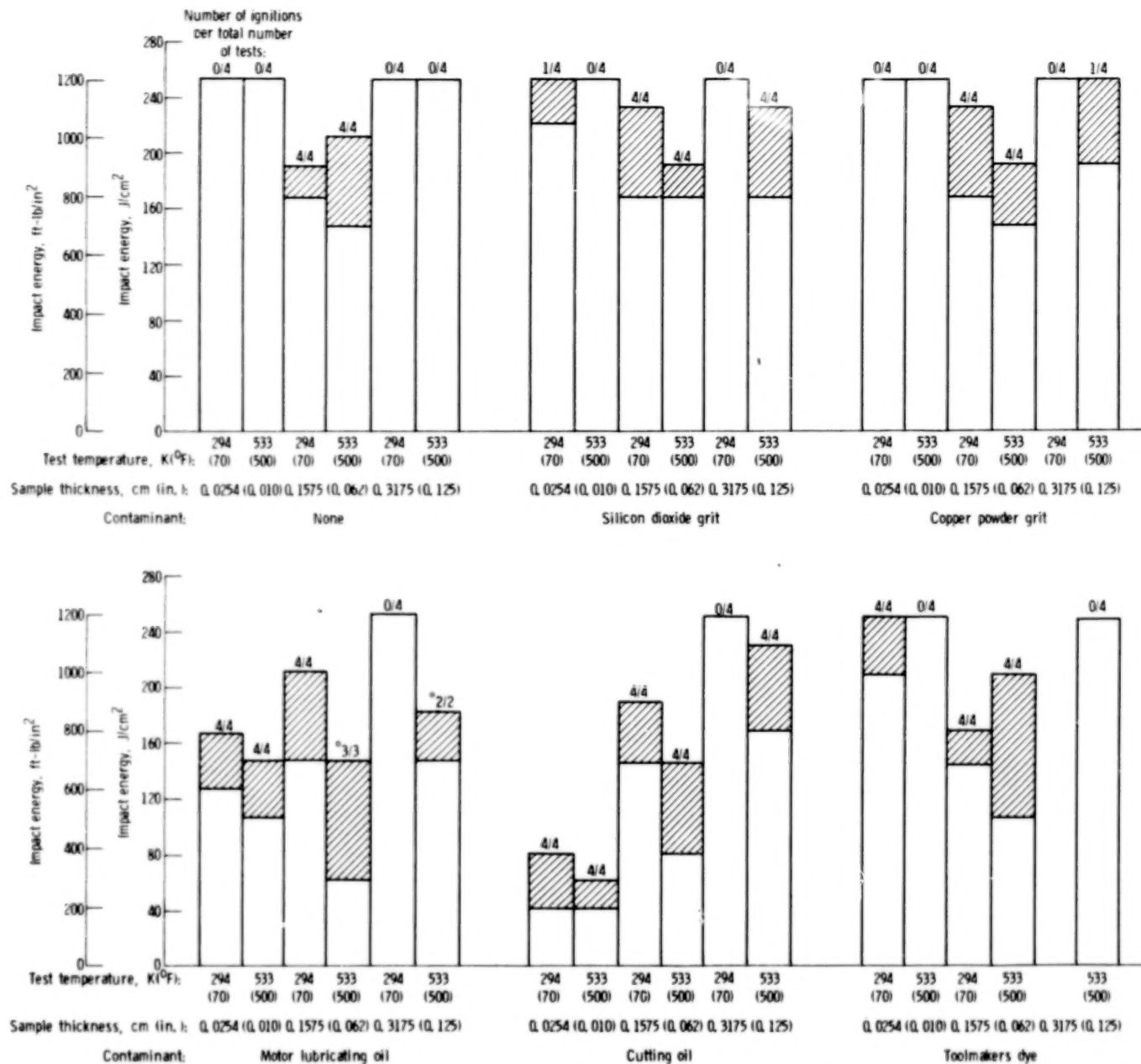


Figure 6. - Mechanical impact ignition threshold regions for 6061-T6 aluminum in centered-sample-cup configuration. Sample diameter, 0.625 cm (0.250 in.); test pressure, 34.57 MPa (5000 psig).

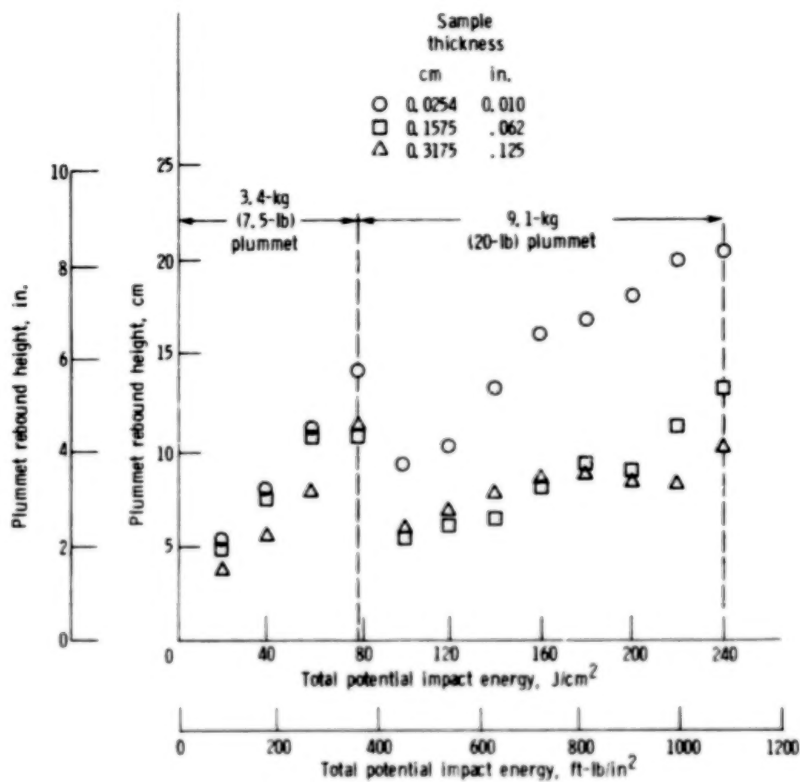


Figure 7. - Plummets rebound height as function of total potential impact energy.

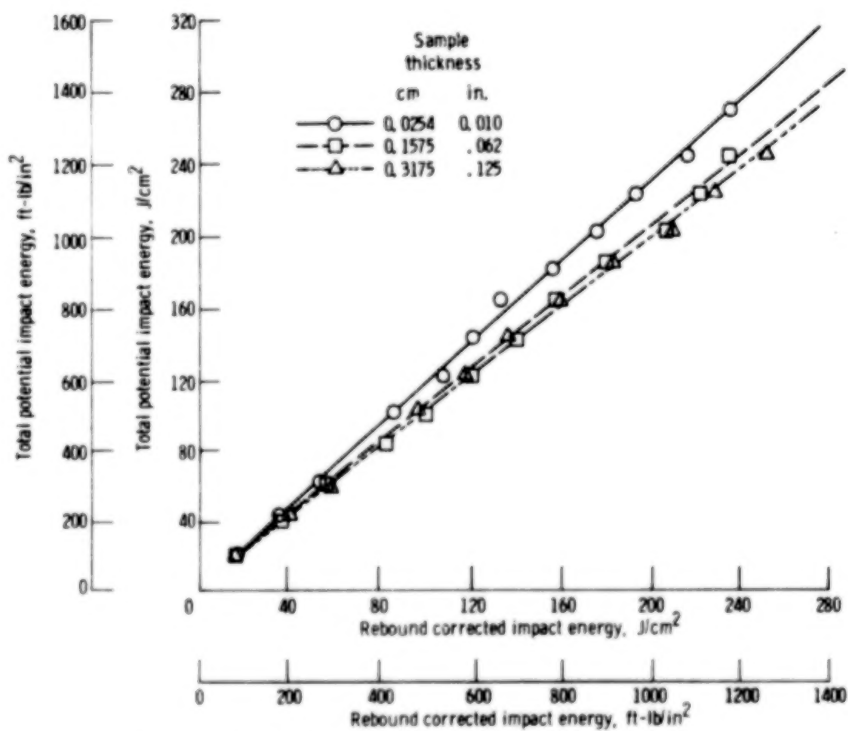


Figure 8. - Potential impact energy as function of rebound corrected impact energy.

